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Orthomitrium tuberculatum (Orthotrichaceae), a New Genus and Species from Guizhou, China

Jette Lewinsky-Haapasaari

Kuopio Museum of Natural History, Myhkyrinkatu 22, FIN-70100 Kuopio, Finland

Marshall R. Crosby

Missouri Botanical Garden, P.O. Box 299, St. Louis, Missouri 63166-0299, U.S.A.

ABSTRACT. *Orthomitrium tuberculatum* gen. et sp. nov. (Orthotrichaceae, Orthotrichoideae) is described from Guizhou, China. The diagnostic characters are: (1) terminal sporophytes on the main (primary) stems, which continue growth by lateral innovations; (2) large, mitrate, plicate calyptrae covering the entire capsules; (3) ovoid or globose, smooth capsule with strongly plicate mouth; (4) single peristome; (5) immersed stomata in upper parts of capsules; and (6) large, multicellular spores. The genus is considered most closely related to *Orthotrichum* and *Muelleriella*.

The family Orthotrichaceae includes acrocarpous mosses, i.e., those with terminal perichaetia and additional growth by lateral innovations. It is further characterized by having small, papillose upper leaf cells, undifferentiated alar cells, large, usually mitriform calyptrae, and diplolepidous peristomes with endostomial segments alternating with the exostome teeth, which have thicker outer layers than inner layers. Vitt (1982) included 14 genera in the family: *Zygodon* Hooker & Taylor, *Stenomitrium* (Mitten) Brotherus, *Orthotrichum* Hedwig, *Muelleriella* Dusén, *Pleurorthotrichum* Brotherus, *Ulota* Weber & Mohr, *Bryodixonia* Sainsbury, *Drummondia* Hooker, *Macrocoma* (C. Müller) Grout, *Macromitrium* Bridel, *Florschuetziella* Vitt, *Groutiella* Steere, *Schlotheimia* Bridel, and *Desmotheca* Lindberg. To these were later added *Amphidium* Schimper (Lewinsky, 1976; Vitt et al., 1993), *Sten-*

bryum Norris & Robinson (Norris & Robinson, 1981), *Leiomitrium* Mitten and *Cardotiella* Vitt (Vitt, 1981), and *Ceuthotheca* Lewinsky-Haapasaari (Lewinsky-Haapasaari, 1994). The Orthotrichaceae are divided into four subfamilies: Zygodontoideae (Limpricht) Brotherus, Orthotrichoideae (Limpricht) Brotherus, Drummondioideae Vitt, and Macromitrioideae (Fleischer) Brotherus (Vitt, 1982). This subdivision is mainly based on stem branching pattern, sporophyte position, and calyptra shape.

More than 60 papers have been published on this family within the last 23 years, and of these 37 within the last 10 years. Thus, in view of the intense degree to which the family has been studied, it was surprising to find a moss among some recent collections from Guizhou Province, China, that clearly belongs to the Orthotrichaceae, but cannot be placed in any of the known genera. The plants have erect or erect-ascending stems with the perichaetia at the end of the primary stems, which continue growth by lateral innovations. This gives the impression of an *Orthotrichum*, an impression supported by the large, mitrate, 16-plicate calyptrae, not split at the bases, with many papillose, slender, yellowish hairs. The capsules, however, are more like those in some species of *Macromitrium*. They are ovoid or globose, smooth, with strongly plicate mouths, and a simple peristome of truncate, hyaline teeth. Unlike *Macromitrium* species, they have immersed stomata present in great numbers on the upper portion of the capsules. Immersed sto-

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mata are known within the family only in the subfamily Orthotrichoideae, from the genus *Muelleriella*, and the *Orthotrichum* subgenera *Orthotrichum*, *Pulchella* (Schimper) Vitt, and *Callistoma* (Iwatsuki & Sharp) Lewinsky. Another striking character of this Chinese moss is its multicellular spores, which usually consist of four cells. Since the younger spores are quite regularly rounded, have one or two interior walls, and outer walls with the same ornamentation as the mature spores, we do not think it is a question of spore-tetrads. Multicellular spores are known within the family in *Muelleriella*, *Drummondia*, and one species of *Orthotrichum*, *O. steerei* Lewinsky.

The moss from Guizhou is here referred to the new genus *Orthomitrium*, which is characterized by the following combination of characters: (1) sporophytes terminal on the main (primary) stems, which continue growth by lateral innovations; (2) large, mitrate, plicate calyptrae covering the entire capsules; (3) ovoid or globose, smooth capsule with strongly plicate mouth; (4) single peristome; (5) numerous immersed stomata in upper parts of capsules; and (6) large, multicellular spores (ca. 50 μm in diameter).

Orthomitrium tuberculatum Lewinsky-Haapa-saari & Crosby, gen. et sp. nov. TYPE: China. Guizhou: Sui-yan Co., Kuan Kuo Shui Forest Reserve, Tai Yan Shan (Sun Summit) and vicinity, on tree, *Crosby 16040* (holotype, MO). Figures 1, 2.

Plantae parvae, nigrescentes. Caules erecti vel erecto-ascendentes. Folia sicca erecta vel erecto-flexuosa, e basibus ovatis lanceolata vel lineari-lanceolata, acute vel rotundate acuta; cellulae superiores folii breviter rectangulae, porosae, membranis crassis, quaeque 1–2(–3) papillis conicis humilibus ornata; cellulae basales folii elongate rectangulae vel rhombicae, membranis crassis, porosis, laevibus. Setae erectae, breves; capsulae laeves, ovoides vel globulares, ad ostia valde plicatae; peristomia singula; stomata immersa, in partibus superioribus capsularum sitae. Calyptrae magnae, mitratae, plicatae. Sporae magnae, circiter 50 μm diameter, multicellulares.

Plants in small tufts among other bryophytes, soft, blackish green to green above, black below. *Stems* up to 2 cm tall, erect or erect-ascending, fastigiately branched above, with a rather thick epidermis, no central strand. *Rhizoids* only present at the extreme stem bases. *Leaves* erect or erect-flexuose when dry, spreading when moist, from ovate bases lanceolate to linear-lanceolate, varying in size and shape with the largest ovate linear-lanceolate leaves near the stem apices, 2–5 $\times$ 0.4–0.8 mm, gradually acuminate, sometimes shortly decurrent, but not with distinct auricles; leaf apices

acute to rounded acute: costae ending shortly below the apices, without stereids; margins plane in short leaves, slightly undulate in longer leaves, recurved to revolute at least in the central part; basal leaf cells elongate rhomboidal to rectangular, porose, with thick, brown, nodose longitudinal walls and thinner transverse walls, smooth, 40–65 $\times$ 4.5–8.0 μm ; transitional leaf cells shorter, with less porose and nodose walls, occasionally with one conical papilla near the end, 14–21 $\times$ 6–13 μm ; upper leaf cells short rectangular, arranged in distinct rows, with thick, nodose, porose walls and 1–2(–3) low conical papillae per cell, 9–12 $\times$ 4.5–7.0 μm . *Gemmae* not seen. *Goniautoicous*. *Perichaetial* and *perigonal leaves* not markedly differentiated. *Perichaetia* at the end of the main stems, which continue growth by lateral innovations. Setae short, 1–3 mm long, slender, straight, with an epidermis of yellow to brown cells and an inner ring of brown cells surrounding a few central hydroids. *Vaginulae* with many long, smooth, yellowish hairs. *Capsules* ovoid to globose when wet, 2.0–2.8 mm long, smooth, erect, emergent, reddish brown below, darker at the strongly plicate mouths, persistent for several seasons; exothecial cells immediately below mouth differentiated in eight stripes of thick-walled dark brown cells, usually four cells wide, alternating with eight paler stripes, usually nine cells wide; further down the cells are short rectangular to quadrate, thick-walled; stomata immersed, half to completely covered by the subsidiary cells, numerous in upper parts of capsules giving young, dry capsules a puckered appearance; annuli of two rings of small, hyaline, thin-walled, almost quadrate cells. *Peristomes* single, no prostomes; exostome of 16 truncate teeth, sometimes partly united, hyaline, but with the areas around the old cell walls yellow and prominent, with a rough ornamentation of horizontal and vertical lines and papillae, with many short, densely set papillae along the edges. *Opercula* erect-rostrate. *Spores* large, multicellular, ca. 50 μm diam., finely papillose. *Calyptrae* large, mitrate, covering the entire capsules, yellow with red-brown apices, 16-plicate, with many hairs reaching to the top; hairs yellow, slightly papillose from protruding cell ends.

Habitat. Epiphytic, mixed with *Ulota* spp.

Due to the erect to erect-ascending primary stems at the end of which the sporophytes are produced, the upper leaf cells with 1–2(–3) conical papillae, the large mitrate calyptrae, and the emergent capsules, *Orthomitrium tuberculatum* can be referred to the subfamily Orthotrichoideae as defined by Vitt (1972, 1982). Within this subfamily it

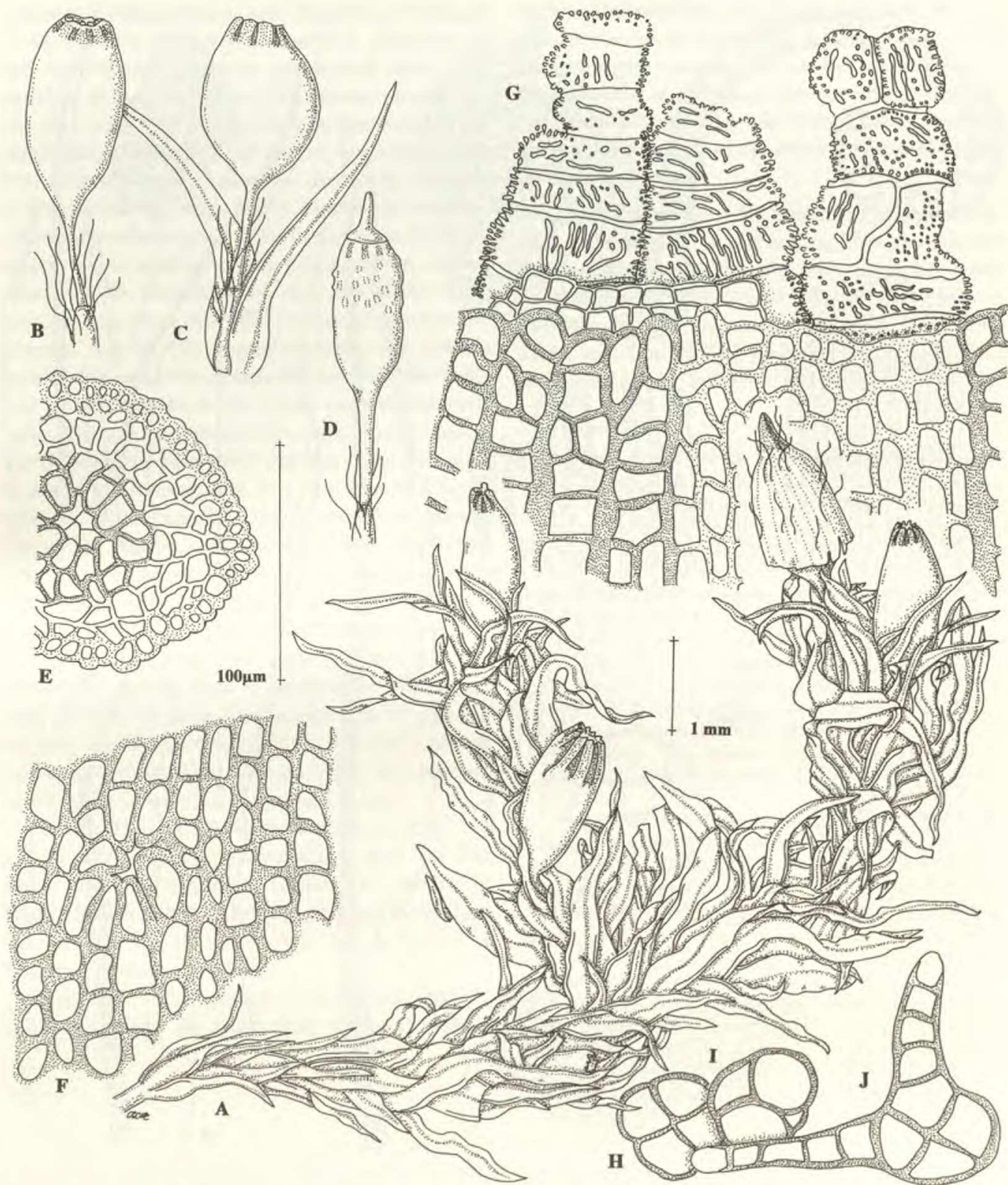


Figure 1. A–J. *Orthomitrium tuberculatum* Lewinsky-Haapasaari & Crosby (Crosby 16040). —A. Habit when dry. —B, C. Mature capsules, dry. —D. Young capsule, dry. —E. Cross section of seta. —F. Stoma from capsule wall. —G. Part of peristome. —H, I. Spores. —J. Germinating spore.

seems most closely related to *Orthotrichum* and *Muelleriella*, which also include species with immersed stomata. This condition is considered an apomorphic character having developed from superficial stomata. In *Orthotrichum* this event is thought to have taken place twice (cf. Lewinsky, 1993). The blackish coloration, the thick-walled

exothecial cells, the smooth capsule wall, and the multicellular spores are also found within *Muelleriella*. These similarities, however, might not indicate these two genera are more closely related. They have quite different ecology, and an adaptation to xeric habitats may have evolved independently in the two genera. Likewise the emergent

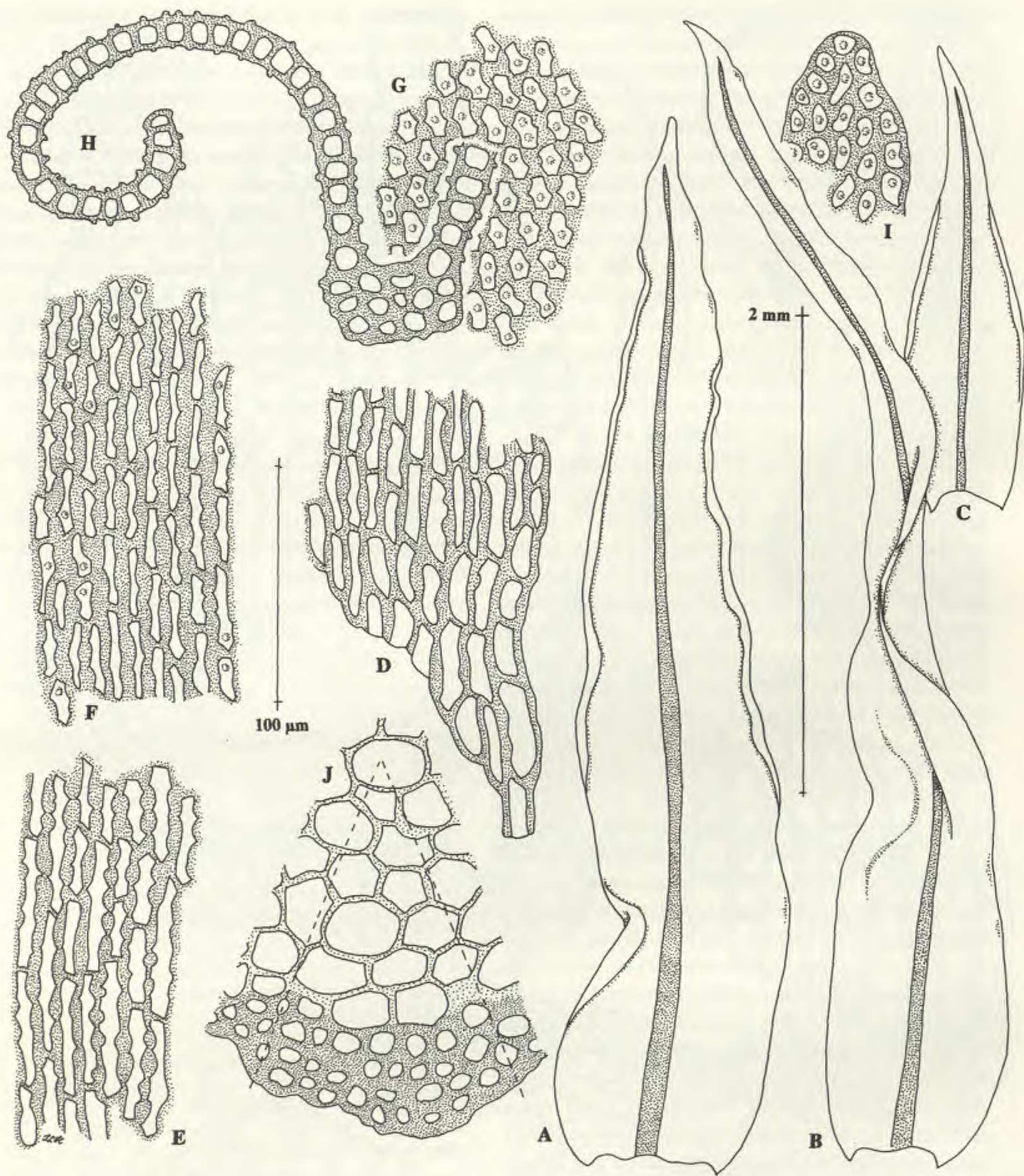


Figure 2. A–J. *Orthomitrium tuberculatum* Lewinsky-Haapasaari & Crosby (Crosby 16040). —A–C. Leaves. —D. Basal leaf corner. —E. Basal leaf cells. —F. Transitional leaf cells. —G. Upper leaf cells. —H. Partial cross section of leaf. —I. Leaf apex. —J. Partial cross section of stem.

capsules and reduced peristomes in *Orthomitrium*, both apomorphic character states, can be regarded as further adaptations to xerophytic habitats. The capsules of *Orthomitrium* are unlike any in the Orthotrichoideae, but resemble through their shape, strongly plicate mouths, and reduced peristomes some of those in the Macromitrioideae. The mosses in this subfamily do, however, have a different

branching pattern, a character considered of great importance when dividing Orthotrichaceae into subfamilies. Further, immersed stomata and multicellular spores are not known from this subfamily.

It can be argued that of the six characters on which this new genus is based, characters 1, 2, and 5 are commonly found in *Orthotrichum*. Character 4, although uncommon, is found in at least three

species of *Orthotrichum*, and character 6 is found in one species (*Orthotrichum steerei*). Therefore, if the individual characters are looked upon, the ovoid to globose capsules with plicate mouths are the only separating character. It is, however, not the individual characters that are of importance, but the combination of characters, just as in the case of *Muelleriella* (cf. Vitt, 1976). Further, if *Orthomitrium tuberculatum* had to be included in *Orthotrichum*, which species would represent the closest relatives? We cannot assign it to any of the three existing subgenera that include taxa with immersed stomata due to the capsule shape, the plicate mouth, the exostome ornamentation, and the position of the stomata in the upper parts of the capsules. There is no intermediate capsule type linking the *Orthomitrium* capsules with the types commonly found in *Orthotrichum*. It is not like in *Macromitrium*, where capsules being irregularly plicate the entire lengths are thought to have developed into capsules being 8-plicate and puckered near the mouths, capsules 4-plicate near the mouths, or not at all plicate (cf. Vitt, 1983). *Orthomitrium tuberculatum* also seems more isolated from other *Orthotrichum* species than *O. callistomum* Brotherus (only member of subg. *Callistoma*) and *O. gymnostomum* Bridel and *O. obtusifolium* Bridel (making up subg. *Orthophyllum* Delogne). This in our eyes justifies the creation of a separate genus.

Distribution. *Orthomitrium tuberculatum* is known only from a single collection from Tai Yan Shan, Guizhou, Southwest China. The locality is about 150 km north of Guiyang, the provincial capital of Guizhou, or about 550 km northeast of Kunming, Yunnan Province.

Etymology. The generic name *Orthomitrium* has been made by combining the two generic

names *Orthotrichum* and *Macromitrium*. The gametophytes of *Orthomitrium* are like those of the first mentioned genus, whereas the sporophytes resemble those of the latter. The specific epithet *tuberculatum* refers to the tuberculate young capsules due to the presence of the many immersed stomata in the upper parts.

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